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The past ten years has seen progress in the understanding of the ultraviolet background of the earth's atmosphere. These airglow, auroral, and scattering emission sources set limits on the usefulness of UV for space observations. They also, however, enable several types of passive remote sensing; such as, electron density profiles, neutral density and composition, and auroral location and strength. The paper describes our measurements and data analysis in these areas. UV imaging of the aurora has been achieved by four experiments, and these are briefly reviewed. UV imaging has opened up a new way to study solar-terrestrial relationships.

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VACUUM ULTRAVIOLET BACKGROUNDS FROM SPACE-TEN YEARS AFTER

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Abstract

The past ten years has seen progress in the understanding of the ultraviolet background of the earth's atmosphere. These airglow, auroral, and scattering emission sources set limits on the usefulness of UV for space observations. They also, however, enable several types of passive remote sensing; such as, electron density profiles, neutral density and composition, and auroral location and strength. The paper describes our measurements and data analysis in these areas. UV imaging of the aurora has been achieved by four experiments, and these are briefly reviewed. UV imaging has opened up a new way to study solar-terrestrial relationships.

INTRODUCTION

Looking back at the earth from space with ultraviolet sensors enables remote sensing from the stratosphere through the ionosphere. The key to the utilization of ultraviolet for this purpose is a thorough understanding of the UV radiation environment of the atmosphere.

In addition to being able to observe sources against the relatively low UV background, the emission from the airglow, aurora, and scattering layers can be used for passive sensing of atmospheric composition and temperatures, ionospheric electron number densities, and the location and strength of the aurora, among the more prominent of near-term applications. For these uses, ab initio models and new observational methods are becoming available.

This paper reviews our progress in the last ten years and prospects for the future. The previous paper[1] appeared shortly after the flight of the S3-4 satellite in 1978 carrying our experiment "VUV Backgrounds". This experiment continued the measurement of the earth's airglow and auroral emission begun by Ogo-4 roughly ten years before that.[2,3]

The most significant development in the last ten years has been the flight of imaging experiments that have allowed study of the auroral oval and its variability. The usefulness of UV imaging for ionospheric and space sensing is so apparent that it is unlikely that any significant program investigating the ionosphere or the magnetosphere will be flown without an ultraviolet imager of some kind.

A-1

When considering use of the ultraviolet, the statement is still sometimes heard that there is nothing known about the UV backgrounds. While the understanding and modelling, particularly in regard to clutter, is less than in the infra-red, much has been learned, and some recommended values will be given.

Another tangible demonstration of growth in the field is the establishment of SPIE conferences devoted to ULTRAVIOLET TECHNOLOGY (Volume 687, 1986; Volume 932, 1988; and Volume 1158, 1989). These have been organized by a committee assembled by the author and Christos Stergis, also of the Geophysics Laboratory, initially at the request of Irving Spiro. Our third conference (Volume 1158) is at the current meeting.

NADIR AND LIMB MEASUREMENTS

The first step in understanding the UV atmospheric environment is to know the mean level and spectral composition of the emission. We are using satellite and shuttle experiments to gain an understanding of the radiance level, spectrum, and limb radiance profile of atmospheric emissions.

VUV Backgrounds, S3-4

At the conference ten years ago, preliminary results were given for measurements from the experiment entitled VUV Backgrounds, which was flown in 1978 on the S3-4 satellite.

The S3-4 experiment and initial measurements have now been described.[4] Measurements cover the 1100-2900 A region with spectrometers and the 1100-1800A region with a filter photometer. The data base from this experiment is still being used to obtain additional information about UV emission during the April-September 1978 period of operation.

Incidently, the previously unknown emission from the nitrogen Lyman-Birge-Hopfield bands can be ascribed to a spacecraft glow at altitudes below about 200 km.[5,6] Measurements made at higher altitudes from the satellite are representative of atmospheric emission only.

HUP, Shuttle STS-4

The Horizon Ultraviolet Program (HUP) experiment[7] was flown on the shuttle flight STS-4 in 1982. Limb profiles in the 1100-1800 A region were made at 20A bandwidth. The same sensor will be reflown on the shuttle in the future at 5A bandwidth, in part to investigate a method to obtain atomic oxygen concentrations.[8] There was no evidence of interference from contaminants in the measurement, leading to the belief that reliable measurements can be made in the UV from the shuttle when gas release periods are avoided.

An initial report on the HUP measurements is available.[9] The flight provided a large number of limb profiles covering the major features of the radiance in the 1100-1800 A region at mid- and equatorial latitudes. Some of the measurements are shown in Figures 1 and 2.

An image could be obtained from any one of a series of preset bands. The spectrometer mode allowed spectra to be obtained in the downward direction, and the photometer mode provided downward looking data at fixed wavelengths. It was in an approximately 800 km polar orbit on an attitude-stabilized satellite.

Unfortunately, the imager failed after about one month in orbit, and the data base is thus extremely small. There is enough data to demonstrate that this method of imaging is feasible.

The imager on the Swedish VIKING satellite was provided by Canada. It used linear arrays to sweep out the image in two filter bands. The data is at the highest time resolution of any obtained so far. This time resolution allows study of the development of auroral motions, as the same field of view can be kept under observation.

AIRS, Polar BEAR Satellite

Our imager experiment entitled Atmospheric/Ionospheric Remote Sensor (AIRS) was flown on the Polar BEAR satellite in a polar orbit at about 1000 km altitude[14,15]. A typical auroral image is shown in Figure 3.

The sensor is conceptually a modification of the AIM instrument flown earlier. This imager provides four simultaneous images of the auroral region using a FUV spectrometer with two slits and photomultiplier detectors for two of the images. The other two utilize a portion of the beam from the earth scanning mirror together with filters and two additional photomultipliers for near UV through 6300A bands.

This experiment is still operating as on the summer of 1989, with a total auroral data base of about 5000 images. In addition, spectra for electron density profile determination[16] and photometer data for clutter analysis[17] have been obtained. Other studies using this still growing data base are in progress.

STATUS AND FUTURE

An updated version of the ultraviolet nadir radiances in the 1000-3000A is shown in Figure 4. The original version of this curve was given in the Handbook of Geophysics[18]. The curves give the maximum nadir radiances as observed with an overhead sun, and the minimum night radiance. Both are at mid-latitude. While a simple chart of this type cannot cover all of the limb viewing and solar illumination conditions, it can serve as an introduction to the UV backgrounds levels that will be seen.

We are in the process of developing another satellite experiment called AURA, which stands for Atmospheric Ultraviolet Radiance Analyzer. The final configeration has not been established as yet, but the goal is to establish imaging, electron density profile determination, and similar applications as validated tools for ionospheric remote sensing.

REFERENCES

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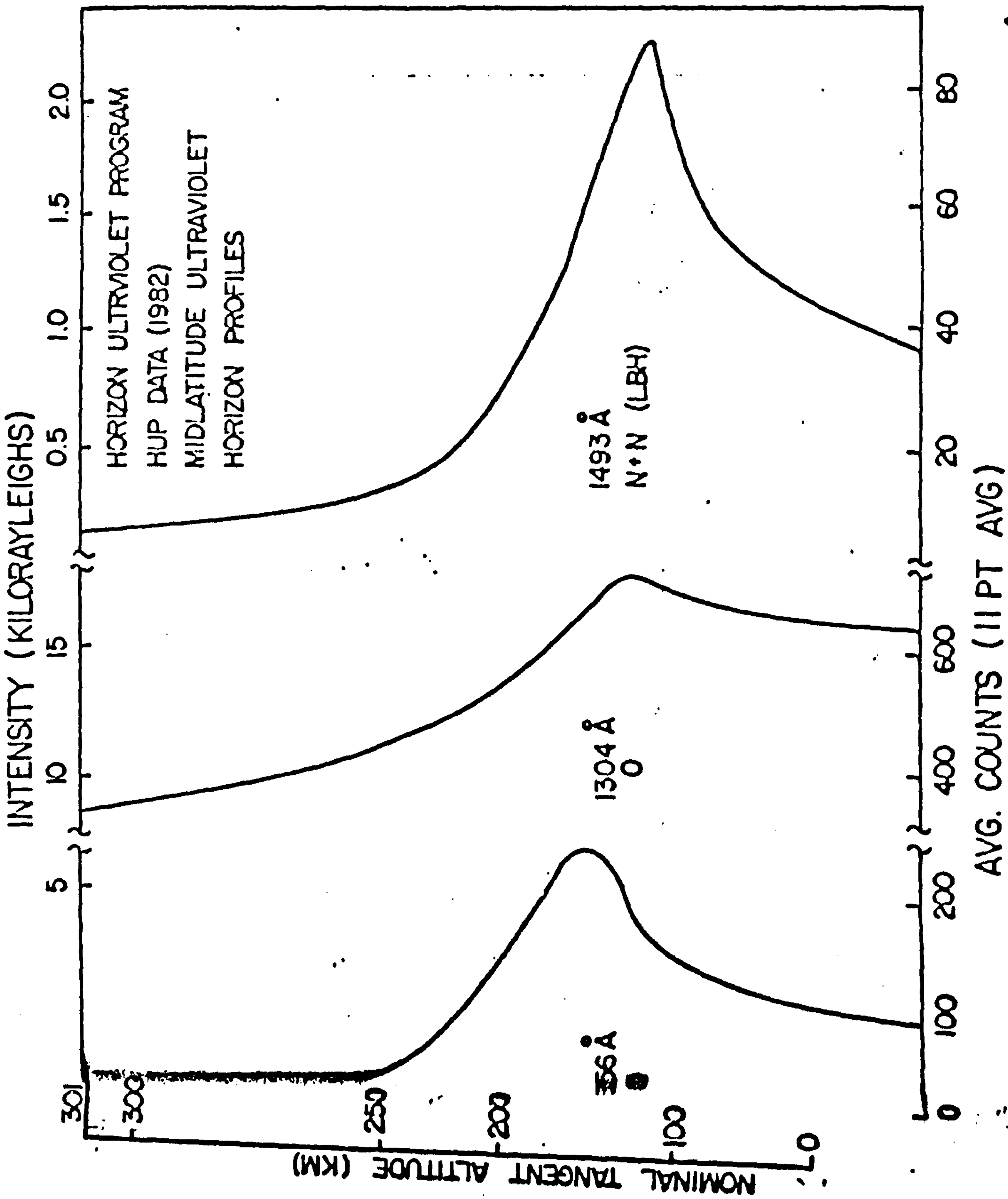
Figure 1. Ultraviolet limb profiles measured by the HUP experiment. Oxygen atomic lines 1304 and 1356A; Nitrogen atomic line 1493A.

Figure 2. Ultraviolet limb profiles measured by the HUP experiment. Nitrogen Lyman-Birge-Hopfield bands.

Figure 3. Auroral image from the Polar BEAR satellite.

Figure 4. Ultraviolet nadir radiance values. Updated version of Handbook of Geophysics curve[18].



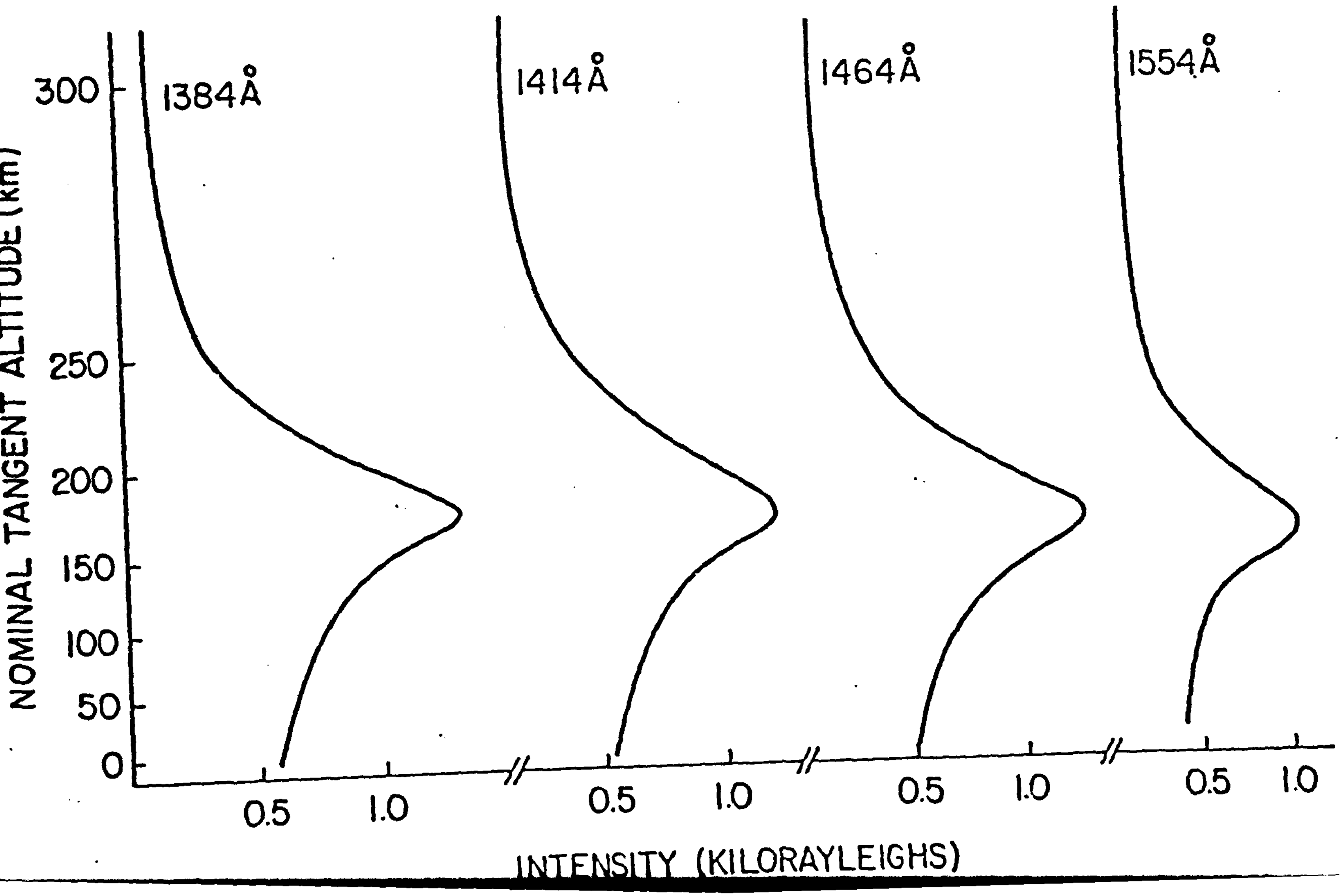
HORIZON ULTRVIOLET PROGRAM
HUP DATA (1982)
MIDLATITUDE ULTRAVIOLET
HORIZON PROFILES
INTENSITY (KILORAYLEIGHS)
AVG. COUNTS (11 PT AVG)
NOMINAL TANGENT ALTITUDE (KM)
1493 Å
N+N (LBH)
1304 Å
O
1356 Å
O

16-56

FIG. 1

MID-LATITUDE LIMB ULTRAVIOLET RADIANCE

AFGL HUP DATA (1982); LOW SZA, N_2 (LBH BANDS), 20Å FWHM



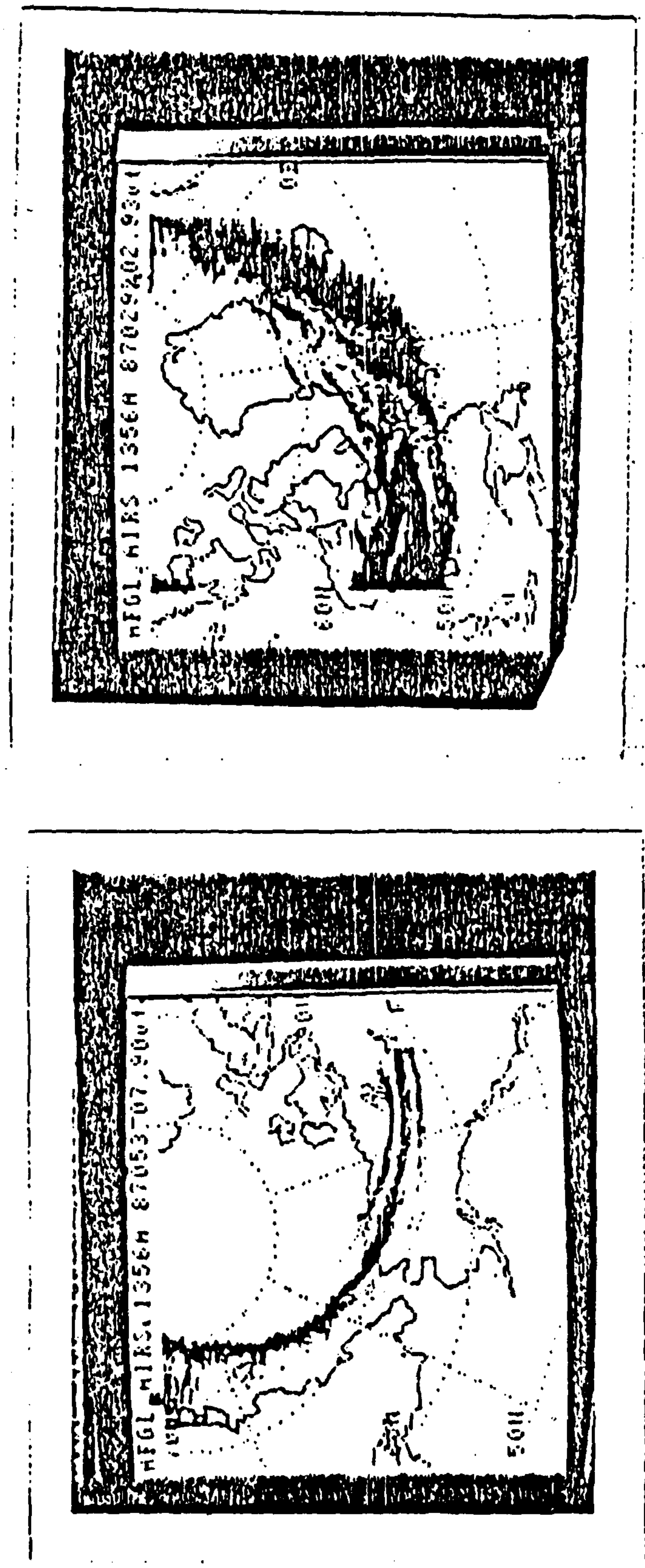
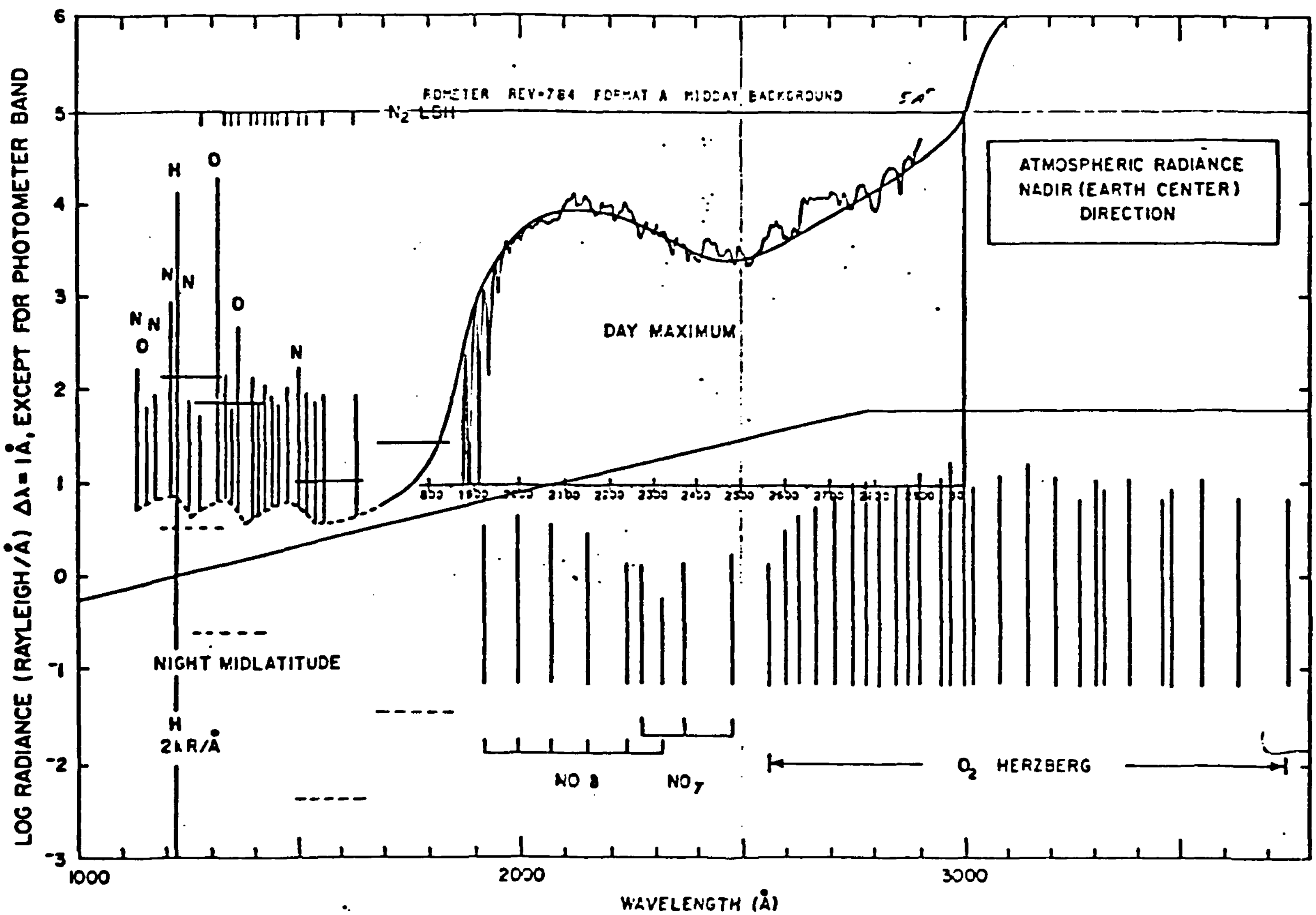


FIG 3



ATMOSPHERIC RADIANCE
NADIR (EARTH CENTER)
DIRECTION
DAY MAXIMUM
NIGHT MIDLATITUDE
N_2 LBH
H
O
N
2 kR/Å
NO β
NO γ
O_2 HERZBERG
LOG RADIANCE (RAYLEIGH/Å) Δλ = 1Å, EXCEPT FOR PHOTOMETER BAND
WAVELENGTH (Å)

Fi/ 1